

REMARKS

This Amendment is submitted in reply to the non-final Office Action mailed on January 26, 2009. A petition for a one month extension of time is submitted herewith. The Director is authorized to charge \$130.00 for the petition for one month extension of time and any additional fees that may be required, or to credit any overpayment to Deposit Account No. 02-1818. If such a withdrawal is made, please indicate the Attorney Docket No. 117682-11 on the account statement.

Claims 1 and 3-18 are pending in this application. Claim 2 was previously canceled. Claim 19 is withdrawn. In the Office Action, Claim 17 is rejected under 35 U.S.C. §112; Claims 1, 3-6, 8-13 and 15-16 are rejected under 35 U.S.C. §102; and Claims 7, 14 and 18 are rejected under 35 U.S.C. §103. In response, Claim 17 has been amended. The amendment does not add new matter. In view of the amendment and/or for at least the reasons set forth below, Applicants respectfully submit that the rejections should be withdrawn.

In the Office Action, Claim 17 is rejected under 35 U.S.C. §112, first paragraph, as allegedly failing to comply with the written description requirement. Specifically, the Patent Office alleges that there is no support for the phrase "wherein the compatibilizer is covalently bound to said first polymer" in the originally filed specification. Applicants respectfully disagree and submit that the compatibilizer being covalently bound to the first polymer is fully supported in the originally filed specification, for example, at page 23, Claim 17.

Applicants respectfully submit that the original claims are part of the specification and provide written description support. Originally filed Claim 17 recites "wherein said compatibilizer is covalently bound to said polymer." The "polymer" is selected from the group consisting of polyethylene, polypropylene, or polyethylene derivatives, which happens to be the same as the "first polymer" of currently pending Claim 17. In pending Claim 17, the "first polymer" is selected from the group consisting of polyethylene, polypropylene or polyethylene derivatives. As a result, the phrase "wherein the compatibilizer is covalently bound to said first polymer" is completely supported in the originally filed specification. Based on at least these noted reasons, Applicants believe that Claim 17 fully complies with 35 U.S.C. §112, first paragraph.

In the Office Action, Claim 17 rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject

matter which Applicants regard as the invention. Specifically, the Patent Office alleges that the term "individual monomer units" in Claim 17 is unclear. In response, Claim 17 has been amended to recite, in part, about 5 wt.% of monomer units of said compatibilizer have the grafting compound attached. The amendment is supported in the specification, for example, at page 5, lines 19-20. Based on at least these noted reasons, Applicants believe that Claim 17 fully complies with 35 U.S.C. §112, second paragraph.

Accordingly, Applicants respectfully request that the rejections of Claim 17 under 35 U.S.C. §112 be withdrawn.

In the Office Action, Claims 1, 3-6 and 8-9 are rejected under 35 U.S.C. §102(a) as anticipated by the printed publication to Yoo et al. ("*Yoo*"). Claims 10-13 and 15-16 are rejected under 35 U.S.C. §102(a) as anticipated by *Yoo*. Claims 7, 14 and 18 are rejected under 35 U.S.C. §103(a) as being unpatentable over *Yoo*. Applicants respectfully disagree with and traverse these rejections for at least the reasons set forth below.

Yoo was published online on November 20, 2001 according to the publishers of *Yoo* as admitted by the Patent Office. See Office Action, notice of reference cited. As a result, the earliest effective reference date of *Yoo* under 35 U.S.C. §102(a) is November 20, 2001.

Applicants respectfully submit an Affidavit of Ya-Jane Wang under 37 C.F.R. §1.131 ("*Affidavit*" attached hereto as Tab 1). This *Affidavit* is submitted to show that the inventors: 1) conceived the claimed invention recited in Claims 1, 3-6 and 8-9 in the United States prior to and 2) diligently worked to reduce the invention to practice from at least prior to the earliest effective reference date of *Yoo* (November 20, 2001) through to the filing of the provisional application on February 28, 2002. As such, Applicants respectfully assert that the *Affidavit* properly obviates the anticipation and obviousness rejections of the pending claims with respect to *Yoo*.

For at least the reasons discussed above, Applicants have shown the conception and diligence related to the constructive reduction to practice of the pending claims of the above-identified prior to the effective date of *Yoo*. Accordingly, Applicants respectfully request that the anticipation and obviousness rejections with respect to the pending claims be reconsidered and the rejections be withdrawn.

For the foregoing reasons, Applicants respectfully request reconsideration of the above-identified patent application and earnestly solicit an early allowance of same. In the event there remains any impediment to allowance of the claims that could be clarified in a telephonic interview, the Examiner is respectfully requested to initiate such an interview with the undersigned.

Respectfully submitted,

K&L GATES LLP

BY 

Robert M. Barrett
Reg. No. 30,142
Customer No. 24573
Phone No. 312-807-4204

Dated: May 11, 2009

TAB 1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Wang, et al.
Appl. No.: 10/506,418
Conf. No.: 8357
Filed: March 30, 2005
Title: BIODEGRADABLE MATERIALS FROM STARCH-GRAFTED POLYMERS
Art Unit: 1796
Examiner: Heincer, Liam J.
Docket No.: 117682-11

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION UNDER 37 C.F.R. § 1.131

Sir:

I, Ya-Jane Wang, hereby state as follows:

1. I am a joint inventor of currently pending Claims 1 and 3-19 of the above-identified patent application and an inventor of the subject matter described and claimed therein. As one of the named inventors, I jointly conceived of the invention recited by pending Claims 1 and 3-19 and worked diligently in filing a patent application at least prior to the earliest effective reference date associated with the publication *Yoo*, namely November 20, 2001, as cited in the Office Action dated January 26, 2009. The facts are set forth below.

2. Prior to November 20, 2001, I, along with co-inventors Zhenhua Sun and Wanjun Liu, ("Inventors") conceived of the invention as described and claimed in the subject application in the United States as evidenced by the following:

- a. Prior to November 20, 2001, Inventors submitted an Invention Disclosure Form ("IDF" attached hereto as Exhibit A) to the Technology Licensing Office at the University of Arkansas ("TLO").

- b. The IDF disclosed detailed information and experimental data directed to improved synthetic polymer and starch blends comprising combinations of a granular and unplasticized starch, a compatibilizer containing a polymer and a grafting compound that is covalently bound to the polymer, and a second polymer, which the pending claims are directed to.
- c. Each of the dates deleted from Exhibit A is prior to November 20, 2001.

3. Prior to November 20, 2001, Inventors and TLO began diligently working in the normal course of business to prepare and file Provisional Application No 60/360,324 (the "Provisional Application" attached hereto as Exhibit B) covering the claimed invention from which the above-identified patent application claims the benefit of. Inventors and TLO diligently continued to work toward preparing and filing the Provisional Application in the normal course of business from before November 20, 2001 up to the filing date of February 28, 2002, as evidenced by the following:

- a. TLO presented the invention disclosed in the IDF to the University of Arkansas Patent and Copyright Committee (the "Committee") on September 28, 2001. The Committee requested Inventor presentation at a following meeting, but authorized the Office of Research and Sponsored Programs to take appropriate action to protect and commercialize the invention disclosed in the IDF.
- b. On November 30, 2001, I presented additional information to the Committee, which formally authorized preparation of the Provisional Application.
- c. December 11, 2001 was the last day of classes for students and faculty at the University of Arkansas, and final exams were from December 13 to 19.

- d. The University of Arkansas was closed for the Christmas and New Years holiday from December 22, 2001 to January 1, 2002.
- e. On January 16, 2002, classes resumed for students and faculty.
- f. On February 19, 2002, the University of Arkansas instructed patent counsel to prepare the Provisional Application based on the IDF.
- g. On February 20, 2002, patent counsel met Inventors to discuss further details for the Provisional Application.
- h. Between February 20, 2002 and February 28, 2002, patent counsel prepared the Provisional Application.
- i. On February 28, 2002, patent counsel filed the Provisional Application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made upon information and belief are believed to be true; and further that these statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of any patent that may issue from this application.

Date: _____

4-28-09

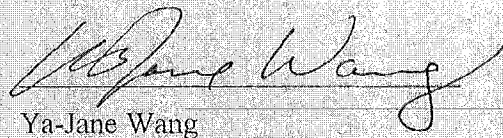

Ya-Jane Wang

EXHIBIT A

University of Arkansas

Invention Disclosure Form



I. Inventor Information

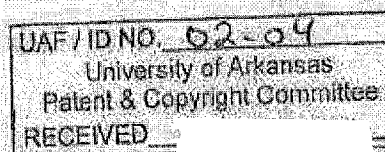
	Full name	Title
a.	Wanjun Liu	Visiting Scientist
b.	Zhenhua Sun	Research Associate
c.	Ya-Jane Wang	Assistant Professor
d.		

	Work Address	Phone/Fax/e-mail
a.	2650 N. Young Avenue, Fayetteville, AR 72704	501-575-2423/501-575-6936/wliu@uark.edu
b.	2650 N. Young Avenue, Fayetteville, AR 72704	501-575-6842/501-575-6936/zsun@uark.edu
c.	2650 N. Young Avenue, Fayetteville, AR 72704	501-575-3871/501-575-6936/yjwang@uark.edu
d.		

	Home Address	Telephone	Citizenship
a.	1540 W. Nettleship St. Apt. #9, Fayetteville, AR 72701	501-571-2363	P.R. China
b.	2338 E. Oaks Dr. #10, Fayetteville, AR 72703	501-443-0518	P.R. China
c.	2490 N. Worthington Way, Fayetteville, AR 72703	501-587-8138	U.S.A.
d.			

II. Invention Information

Invention Title: Biodegradable Materials from Starch-filled Polyethylene



Please give a brief description of the invention, making sure that you answer one or more of the following questions:

1.) Is the invention a new process, composition of matter, a device, or one or more products?

2.) Is it a new use for, or an improvement to, an existing product or process?

Is the invention a work of authorship (including computer software)?

This invention is an improvement of existing products and/or process.

Based on this description, pick out and expand on the novel and unusual features of the invention. How does the invention differ from present technology? What problems does it solve, or what advantages does it possess?

A commercially available compatibilizer (polyethylene grafted maleic anhydride [PE-g-MA]) is identified to be capable of interacting with both polyethylene (PE) and granular starch to enable starch become part of the resulting matrix during the extrusion process without the addition of plasticizer, which is a small molecular acting by lowering the glass transition of the polymers. As the compatibilizer is to improve the interfacial interaction between polymer and filler; thus granular starch will no longer disrupt continuity of PE, consequently the deterioration effect from the addition of filler starch to PE is significantly improved, particularly when starch addition is over 20%. Granular starch will be used instead of plasticized starch; thus disadvantages from the addition of plasticizer, such as moisture absorption and reduction of mechanical properties, will be eliminated. Additionally, the finished materials also show an improved appearance because of the improvement in PE-starch interaction.



Fig. 1a. PE/Corn starch (100/25)

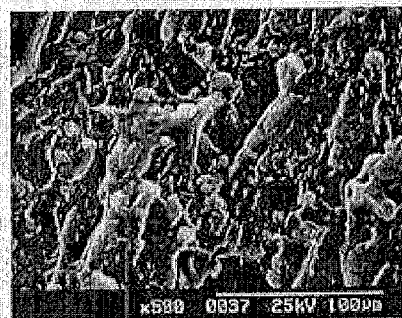


Fig. 1b. PE/Corn starch/PE-g-MA (100/25/2.5)

The scanning electron micrograms of liquid nitrogen fractured surface of PE/granular corn starch samples reflect the phase morphology of the matrix and particles (Fig. 1a and 1b). Strong chemical interactions between PE-g-MA and starch can be observed in the presence of compatibilizer (Fig. 1b) compared with the sample with no compatibilizer (Fig. 1a). The compatibilizer enables granular starch become part of the PE matrix through compatibilization effect and will be not leached out after processing.

Compatibilizer improves the mechanical properties of PE/starch and plasticizer is found to be detrimental to the finished products. See attached Tables 1-4. In comparison, the addition of glycerol (plasticizer) not only decreases the mechanical properties of starch-filled PE but also has a negative effect on the mechanical properties of starch-filled PE after one month of storage because glycerol is not compatible with PE.

Therefore this invention consists of three indispensable components: a compatibilizer (PE-g-MA), granular starch as the filler, and no plasticizer required. The process of incorporating compatibilizer is easy by mechanical blending of mix PE, starch, and compatibilizer prior to extrusion. By using granular starch, no additional processing step is needed to prepare plasticized or gelatinized starch. The starch can be from different botanical sources, such as corn, rice, and potato, and can be either in unmodified or modified

form. PE can also be from different types, such as liner low density PE or high density PE. This invention will make a significant contribution to the environment by substituting bio-based starch (renewable and biodegradable) for petroleum-based PE. It is also very important to note that the use of starch to replace PE significantly (~15%) reduces production cost. For example, corn starch costs 10-15¢/pound vs. PE at 70-100¢/pound.

If not indicated previously, what are the possible uses for the invention? In addition to immediate applications, are there other uses that might be realized in the future?

This invention can be applied to any products that currently use PE or any potential PE-containing products.

Does the invention possess disadvantages or limitations? Can they be overcome? How?

The addition of granular starch over a certain percentage (>30%) presents a potential challenge to process and the amount of starch that can be added to PE depends upon the applications.

What is the earliest date and place the invention was conceived (Identify persons and records to support date and place)?

A research proposal by Ya-Jane Wang and Zhenhua Sun submitted to the Arkansas Agriculture Experiment Station Research Incentive Program on _____ stated the idea of this invention.

Please provide the date and present location of first sketch, drawing or photo and first written description (such as, notebook entries, etc.).

The research proposal submitted to the Arkansas Agriculture Experiment Station Research Incentive Program dated _____

What was the date and place of completion of first operating model or full-size device and its present location:

What was the date and place of first test or operation and the results (including name and addresses of witnesses, and present location of records)?

The first test sample was made using a ThermoHaake twin-screw extruder on _____ at the pilot plant of the Food Science department. Mr. Qingling Zhang (1175 W. Leroy Pond Dr., Fayetteville, AR 72701) was the witness. Dr. Wanjun Liu keeps all the test samples and records in Room C7, Food Science Building.

III. Other Pertinent Information

Please list date, place, and circumstances of first public disclosure.

NA

Please list any publications including theses, reports, preprints, and reprints pertaining to the invention. Please include publication date and attach copies insofar as possible. Include manuscripts for publication (submitted or not), news

Disclosure of this invention, to the public, prior to the actual patent filing date will negate nearly all opportunity for patent protection in foreign countries. Hence, the response to this item is very important.

Should this invention be protected in: (Please check one)

US Only

US and Foreign

If you check U.S./Foreign, please provide a justification based on the manufacturing and/or economic market.

Any plastic company or polyethylene producing company will be benefited from this invention by replacing part of PE with starch to produce more cost effective, more environmentally friendly, more biodegradable starch-filled PE products.

Signature(s) of inventor(s) and date:

Wangjin Lin

Sept. 19, 2001

Phab S

09/19/2001

Yafang Wang

9/20/2001

Approval by Department Chairman and Dean:

[Signature]

9/20/01

Department Chair

date

D. P. Weidenmann

9/20/01

College Dean

date

Use additional sheets to elaborate on answers to questions and to provide any other helpful data.

PE/Corn starch/Plasticizer	Without Compatibilizer		With Compatibilizer	
	Tensile Strength (MPa)	Elongation at Break (%)	Tensile Strength (MPa)	Elongation at Break (%)
100/0/0	13.84	728		
100/5/0	12.93	709	13.06	703
100/10/0	12.76	613	12.61	610
100/15/0	12.67	598	11.72	600
100/20/0	10.06	459	11.50	548
100/25/0	8.72	278	10.98	478

Table 2. The effect of plasticizer (glycerol, 25% based on starch weight) on the on the tensile properties of PE/corn starch with compatibilizer

PE/Corn starch /Compatibilizer (PE-g-MA)	Without Plasticizer		With Plasticizer	
	Tensile Strength (MPa)	Elongation at Break (%)	Tensile Strength (MPa)	Elongation at Break (%)
100/5/0.5	13.06	703	13.73	663
100/10/1.0	12.61	610	11.75	531
100/15/1.5	11.72	600	10.75	556
100/20/2.0	11.50	548	11.20	237

Table 3. The effect of storage on the tensile properties of PE/corn starch without compatibilizer but with plasticizer (glycerol, 25% based on starch weight)

PE/Corn starch/Plasticizer	Tensile Strength (MPa)	Elongation at Break (%)	After one-month storage	
			Tensile Strength (MPa)	Elongation at Break (%)
100/5/1.25	13.62	649	12.35	597
100/10/2.5	13.16	605	11.08	503
100/15/3.75	12.37	541	11.70	86
100/20/5.0	12.23	437	11.26	96
100/30/7.5	12.61	181	11.48	57

Table 4. The effect of storage on the tensile properties of PE/corn starch without compatibilizer and without plasticizer

PE/Corn starch/Plasticizer	Tensile Strength (MPa)	Elongation at Break (%)	After one-month storage	
			Tensile Strength (MPa)	Elongation at Break (%)
100/5/0	12.93	709	13.65	679
100/10/0	12.76	613	12.52	607
100/15/0	12.67	598	9.87	514
100/20/0	10.06	459	9.71	465

Title: Blends of Modified Starches and Synthetic Polymers as Biodegradable Materials

Proposal Program: Research Initiation

Principle Investigator: Ya-Jane Wang, Ph.D.
Assistant Professor of Food Science Department

Co-Principle Investigator: Zhenhua Sun, Ph.D.
Research Associate of Food Science Department

Funding Period: Two years

Total Funding Requested: \$10,000 per year

Date:

Introduction

Research on biodegradable polymers has been very active owing to concerns related to the environmental pollution by nondegradable plastic wastes. Using starches from various botanical sources to partially replace conventional plastics is widely investigated due to the facts that they are among the most abundant and inexpensive biopolymers and they can be easily degraded by naturally occurring microorganisms. However, many obstacles still need to be overcome before more applications can be developed and commercialized.

It is generally accepted that starch must be combined with other materials, like synthetic polymers, in order to produce satisfactory products because starch alone forms a brittle film that is sensitive to water (Scott and Gilead, 1995). In last 30 years, various synthetic polymers have been combined with starches to prepare biodegradable plastics with starch as the major component (starch content 50% or higher), such as ethylene-propylene copolymers (Bhattacharya, et. al., 1995), low-density polyethylene (LDPE) (Arvanitoyannis, et. al., 1997), polycaprolactone (PCL) (Choi, et. al., 1999), poly(ester-urethanes) (TPU) (Seidenstucker and Fritz, 1999), poly(ethylene-co-acrylic acid) (EAA) (Fanta, et. al., 1990, 1992; Otey, et. al., 1977), polylactic acid (PLA) (Fan, 1999), poly(methyl acrylate) (PMAA) (Dennenberg, et. al., 1978; Patil and Fanta, 1993), poly(methyl methacrylate) (PMMA) (Kollengode, 1996), polystyrene (PS) (Kollengode, 1996), and polyvinyl alcohols (PVAs) (Lawton and Fanta, 1994; Okaya, et. al., 1992).

However, most blends exhibit very poor mechanical properties probably because most synthetic polymers are not miscible with starch with the exception of starch/EAA. Extrusion-blown starch-EAA films exhibit uniform, flexible, and good physical properties, despite of significant differences in physical and chemical properties between the two polymers. The ability of these two polymers to form blends with good mechanical properties is largely due to the formation of helical inclusion complexes of starch and EAA (Fanta, et. al., 1990). Fourier transform infrared (FTIR) experiments suggest that most of the EAA carboxyl groups (>50%) were hydrogen bonded to the hydroxyl groups of starch when the ratio of EAA/starch is less than 1 (Shogren, et. al., 1992). A starch-based blown film was successfully prepared by combining starch, EAA, ammonium hydroxide, and water, and then heated with stirring until the starch was gelatinized to obtain a uniform mixture. When aqueous ammonia was omitted from the formulation, mixing of the two polymers was inhibited by the hydrophobic nature of EAA (Fanta, et. al., 1992).

The major difficulties of incorporating starch into plastics are its hydrophilicity, its tendency of forming crystalline structure through extensive hydrogen bonding to give brittle property, and its incompatibility with regular synthetic polymers. When starch and a synthetic polymer are blended, because of their incompatibility, the synthetic polymer is the dispersed phase distributed in the starch matrix when starch is the major component of the blend. The dispersed polymer probably renders the final products more brittle because of poor interaction between the dispersed phase and the starch matrix. Therefore, blending of regular synthetic polymers with starch will not improve the mechanical properties of starch-based plastics, and compatible blends are required to make biodegradable materials from starch. In compatible blends, starch and synthetic polymers will attract each other to form a uniform mixture on a

molecular level. Therefore, the synthetic polymer macromolecules will alter the hydrogen bonding and prevent crystallization of starch, which is believed to dramatically improve the mechanical properties of starch-based plastics.

The best way of enhancing the compatibility of polymers is to introduce specific interactions between constituents of the individual polymers. The potentially beneficial interactions range from strong ionic interactions to weak disperse interactions. Hydrogen bonding is an important specific interaction that has been proposed for many compatible polymer systems. In this project, we will focus on water-soluble polymers, because polymers exhibiting water solubility generally have functional groups with high polarity and sites for specific interactions with other molecular species with complementary structures (Olabisi, et. al. 1979).

Water-soluble polymers can be divided into three groups: polymeric acids and their salts, cationic polyelectrolytes, and non-ionic water-soluble polymers (Bekturov and Bakauova, 1986). Polymeric acids include poly(acrylic acid) (PAA), poly(methacrylic acid) (PMA) and poly(ethylene-co-acrylic acid) (EAA), polysulfonic acids, polyphosphates, carboxymethyl cellulose, and other polyacids. Polymeric acids often form compatible and water insoluble blends with cationic polyelectrolytes, and non-ionic polymers, such as polyethylene oxide (PEO), poly(vinyl pyrrolidone) (PVP), and poly(N,N-dimethylaminoethyl methacrylate) (PDMA). PEO, PVP, and PDMA have been shown to form water-insoluble complexes with PAA, PMA, and carboxymethyl cellulose (Olabisi, et. al. 1979). Therefore, in this study, chemical modification of starch will be used to introduce specific chemical groups into starch macromolecules, which can form specific interactions with water-soluble synthetic polymers, such as PAA, PMA, EAA, PEO, and PVP.

Chemical modification of starch changes the functionality of starch. The chemistry in the modification of starch primarily involves reactions associated with the hydroxyl groups of starch polymer. Derivatization via ether or ester formation, oxidation of the hydroxyl groups to carbonyl or carboxylic groups, and hydrolysis of glycosidic bonds are some of the major mechanisms of chemical modification (Wurzburg, 1986)

Two different methods will be used in this study to modify starch: 1. Cationization of starch. No work has been done on incorporating cationic starch to improve the mechanical properties of starch-based plastics. It is possible that the introduced cationic groups will change the crystallization behavior, alter hydrogen-bonding interaction, and eventually change the properties of starch. Furthermore, cationic starch potentially interacts with PAA, PMA and EAA, since cationic groups will attract acrylic acid groups strongly, and have a much better chance to form compatible blends with PAA, PMA, and EAA. 2. Grafting acrylic acid and methacrylic acid groups into starch macromolecules. Since PAA and PMA can form strong interaction with PEO, PVP, and PDMA, starch-g-PAA and starch-g-PMA will interact with PEO, PVP, and PDMA through their PAA and PMA graft chains, which will enhance the compatibility and mechanical properties of starch/PEO, starch/PVP blends.

This research will focus on the development of biodegradable polymer materials from starch, a renewable agricultural resource, to partially replace synthetic polymer materials. **Two specific research objectives** will be accomplished to improve poor mechanical properties of starch-based biodegradable materials.

1. Characterization of blends of cationic starch/polymeric acids

To improve the compatibility and mechanical properties of blends of starch/polymer blend, chemical modification will be employed to introduce chemical groups into starch, which can interact with PAA, PMA and EAA. Since PAA, PMA, and EAA are acidic polymers, it is possible that they will interact strongly with cationic starch via ionic bonding. In this objective, cationic starch will be synthesized with different degrees of substitution (DS). The blends of cationic starch/PAA, cationic starch/PMA, and cationic starch/EAA will be prepared and characterized by various advanced techniques, such as dynamic mechanical analysis (DMA), differential scanning calorimeter (DSC), scanning electron microscopy (SEM), and Fourier transform infrared (FTIR). The structure, morphology, thermal mechanical properties, and interactions between the two polymers of blends will be characterized. The effect of blend composition, DS of cationic starch on the structure and properties of the blends will be studied.

2. Characterization of blends of starch-g-PAA, starch-g-PMA with water-soluble non-ionic polymers

Graft polymerization of acrylic acid and methacrylic acid onto starch macromolecules will be used to make starch-g-PAA and starch-g-PMA. Since PAA and PMA are compatible with a lot of water-soluble non-ionic polymers, such as PEO, PVP, and PDMA, the graft polymerization will enable starch-g-PAA and starch-g-PMA to form compatible blends with PEO, PVP, and PDMA. In this objective, starch-g-PAA and starch-g-PMA with different graft degree will be synthesized; the blends of starch-g-PAA/PEO, starch-g-PMA/PEO, starch-g-PAA/PVP, and starch-g-PMA/PVP will be prepared and characterized by different techniques. The structure, morphology, thermal mechanical properties, and interactions between the two polymers of blends will be characterized.

Justification

The funding is requested for the development of sufficient preliminary data needed for submission of a competitive federal grant proposal. The principle investigator, Dr. Ya-Jane Wang, is in the first year of her tenure-track faculty appointment and in need of funding to conduct preliminary work.

Rational and Significance

This research is to develop biodegradable materials based on starch and synthetic polymers. Many research groups are working on this subject; however, most of them use a trial-and-error approach to develop starch-based biodegradable materials without understanding the mechanism of starch-polymer interactions. In this project, a novel approach will be undertaken to understand their interactions and to improve their mechanical properties based on a sound theory. Because of the nature of starch and commonly used synthetic polymers, presently available biodegradable materials have poor mechanical properties, which is believed by the authors to be a result of almost no interactions between starch and those polymers. This project will be conducted based on a "compatibility theory". If the individual components of a blend are compatible, the finished film from the blend will have good mechanical properties; if the individual components are not compatible, the finished film will have poor properties. Cationization and graft polymerization will be used in this project to improve the compatibility of starch and synthetic polymers. These products are modified by chemical means to attach functional groups to starch, which enable starch to be more compatible with synthetic polymers. Once the compatibility theory is validated, more applications and better products for biodegradable market can be explored and developed to effectively resolve contamination from petroleum-based plastics.

Literature Cited

- Arvanitoyannis, I., E. Psomiadou, and C. G. Biliaderis, 1997. Biodegradable films made from low density polyethylene (LDPE), ethylene acrylic acid (EAA), polycaprolactone (PCL) and wheat starch for food packaging applications: part 3. *Starch/Stärke*, 49, 306-322.
- Bekturov, E. A. and Z. Kh. Bakauova, 1986. *Synthetic water-soluble polymers in solution*. Huthig & Wepf Verlag Basel, Heidelberg.
- Bhattacharya, M., U. R. Vaidya, D. Zhang, and R. Narayan, 1995. Properties of blends of starch and synthetic polymers containing anhydride groups. II. Effect of amylopectin to amylose ratio in starch. *J. Appl. Polym. Sci.*, 57, 539-554.
- Choi, E., C. Kim, and J. Park, 1999. Synthesis and characterization of starch-g-polycaprolactone copolymer. *Macromolecules*, 32, 7402-7408.
- Dennenberg, R. J., R. J. Bothast, and T. P. Abbott, 1978. A new biodegradable plastic made from starch graft poly(methyl acrylate) copolymer. *J. Appl. Polym. Sci.*, 22, 459-465.
- Fan, Q., 1999. Preparation and characterization of starch-based loose-fill packaging foams. *Ph.D. Dissertation*, University of Nebraska-Lincoln.
- Fanta, G. F., C. L. Swanson, and W. M. Doane, 1990. Composites of starch and poly(ethylene-co-acrylic acid). Complexing between polymeric components. *J. Appl. Polym. Sci.*, 40, 811-821.